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An Efficient Finger Print Enhancement Filtering Technique with High Boost Gaussian Filter (HBG)

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Abstract: Finger print recognition technique is one of the challenging tasks in biometric security system. Apart from the Automatic Fingerprint Identification system (AFPIS) the offline and latent finger prints are still suffering in quality issue, hence, there is need for image enhancement. Now, a day's various filters were used for fingerprint enhancement, but no one of them has proved 100% quality on finger prints. By considering these issues we analysed various filters and proposed a new methodology for finger print pre-processing. In this paper we used the high boost filter and Gaussian filter for efficient finger print image quality. In our proposed methodology the original is filtered using High Pass filter and the Gaussian filter for noise removal. Finally, High Boost filter is apply for better enhancement and the performance of the image quality is measured using Mean Squared Error (MSE) and Peak Signal Noise Ratio (PSNR). It is proved that our methodology provides better result in improving the image quality and better enhancement.

Key words: Image Enhancement, high boost filter, Gaussian filter, MSE, PSNR.

I . INTRODUCTION

Due to the rapid growth in the Information technology the security system was suffering with lot of issues. Today, criminals were entered into the Information technology called cyber crime leads to huge issues in every sectors in daily life. Lot of security systems has emerged to solve these issues such as with password, username, secret codes, but these failed due to the cracker and cyber attacks. In order to solve such security issues the biometric system was emerged with various features such as fingerprints recognition, IRIS, gait, palm print, voice, Signatures etc.

Fingerprint recognition is the most widely used biometric system for human identification. Generally, finger prints are the pattern of human fingers which are called as minutia i.e. ridges and valleys. The finger print acquisition can be classified into two major techniques (i) Automatic Fingerprint Recognition[7] with the help of online sensors or other devices. Another technique on latent prints which are obtained by various medias such as ink, powder, paper etc, mostly they are by crime sections. The finger prints are classified into various types in whorl, left loop, right loop, trend arch, arch etc. Mostly, the fingerprint consists of ridges ending and ridge bifurcation. Apart from AIFS the latent finger prints are affected by external agents called noise. The noise is one kind of feature which disturbs the real finger print pattern and makes the identification process inefficient. So, there is need to eliminate this noise, and to recover original finger print from noises. This can be done by a process called pre-processing.

Pre-processing is a method of eliminating or reducing the noise presents in the finger prints. It consists of various techniques such as binarization, normalization, thinning. Another method which is done by various filters these are efficient filters are also available to reduce noise. Finger print enhancement is the method of improving the quality of the image by increasing contrast, brightness, sharpness etc. The various filter and methods used for pre-processing are discussed in the following sections.

II. RELATED WORK

The quality of the image is evaluated by the error-free image and these can be accomplish by pre-processing technique are applied on image. Histogram is applied on 256 gray scale fingerprint image with threshold value then the image is to be binarized and the median filter is applied on the binary image for noise elimination[2]. Another method[3] for enhancing the quality of finger print images with directional filtering of Gabor filter and second order derivative of Gaussian filter which applied on pyramid scheme. In this method the another used three filter for different processes. In [4] the author applied the median filter directly on gray scale image and the binary images to make better image quality and the performance is evaluates by statistical correlation and computational time. This is simple process but cannot eliminate the maximum noise.

Fuzzy based filtering technique [5] is one of the most efficient pre-processing technique. In this a modelling approach is applied for noise removing and improves the luminosity of the ridges. The filter used her to the fuzzy filter but this pre-processing take place in six stages. Another approach[6] DOG based fingerprint enhancement scheme was

used for enhancement by decomposes the input image by laplacian pyramid framework and band pass filter is applied for the local contrast.

Kanagalakshmi et al. [7] author used frequency domain enhancement algorithm on Log Gabor filter in FFT domain. In this pre-processing method the MSE and PSNR value is used for the quality measures. In this system the technique consists of more stages. Here fast Fourier transform is applied on input image and Log Gaber filter is applied then inverse FFT is applied. One approach[8] was used for image enhancement is by converting the image into binary image then dilation, thinning and removing the unwanted portion. In this method the real intensity of the original image may get lost.

Binarization plays a major role in fingerprint image enhancement. In this method[9] the binarization is done by frequency domain analysis. Various filters are used in the process median filter is applied for smoothening the image. An image enhancement method [10] by developing mehtre method for directional image. In this techniques the enhancement is done by using block filtering , histogram equalization and high pass filtering. Two types of operation has be considered here pixel wise operation and block wise operatio

An adaptive wiener filter with thresholding [12] is applied for better image enhancement. A fast lifting wavelet transform is used for thresholding and the ANF with Bayer Shrine thresholding lot of processing stages has used for this method. A methodology [14] using modified Gabor filter is used for enhancement. It consists of independent parameter selection of image and in this methodology the image structure was preserved. Another framework for improving low quality fingerprint images [16] by eliminating the noise by various filter and makes and enhanced the structure of ridges and valleys. A set of operations such as frequency and spatial domain filtering, local orientation estimation, local frequency estimation and morphological operation.

Keokanlaya [13] used a directional wavelet transform and second order derivative Gaussian filter. In this process the original input image is decomposed into sub-image. Then the second order derivative of Gaussian filter is to tuning up the image features.

III. METHODOLOGY

3.1 Filters

Generally filters are used to filter unwanted things or object in a spatial domain or surface. In digital image processing, mostly the images are affected by various noises. The main objectives of the filters are to improve the quality of image by enhancing is to improve interoperability of the information present in the images for human visual. A general structure of a filter mask is as follows.

-1	-1	-1
-1	N	-1
-1	-1	-1

1	7	8
3	5	9
5	6	1

3.2 Frequency and Spatial Filters.

The frequency domain technique is based on the convolution theorem. It decomposes an image from its spatial domain form of brightness into frequency domain components and is represented as the following equation

$g(x,y) = h(x,y) * f(x,y)$ 1

where $f(x,y)$ is the input image , $h(x,y)$ is a position invariant operator and $g(x,y)$is the resultant image from the convolution theorm.

$G(u,v) = H(u,v)F(u,v)$ 2

Where G,H,F are the fourier transform of g, h, frespectively.

The transform H(u,v) is called transfer function of the process. Here the edge in f(x,y) can be boosted by using H(u,v) to emphasis the high frequency component of F(u,v).

In case of spatial filter works on pixels in the neighbourhood of the pixel i.e sub image is defined. The operation on sub image pixels is defined using mask or filter with the same dimension.

3.3 Low pass filter

Low- pass filter is a type of filter used for the image enhancement. It preserves the smooth region in the image and removes the sharp variation leading to blurring effect. A3 by 3 low pass spatial matrix is presented below.

$$3 \times 3 = \left(\frac{1}{9}\right) \times \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

$$5 \times 5 = \frac{1}{25} \times \begin{pmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{pmatrix}$$

3.4 Median filter

Median filter, the most prominently used impulse noise removing filter, provides better removal of impulse noise from corrupted images by replacing the individual pixels of the image as the name suggests by the median value of the gray level The median of a set of values is such that half of its values in the set are below the median value and half of them are above it and so is the most acceptable value than any other image statistics value for replacing the impulse corrupted pixel of a noisy image for if there is an impulse in the set chosen to determine the median it will strictly lie at the ends of the set and the chance of identifying an impulse as a median to replace the image pixel is very less.

A commonly used non-linear operator is the median, a special type of low-pass filter. The median filter takes an area of an image (3x3, 5x5, 7x7, etc.), sorts out all the pixel values in that area, and replaces the center pixel with the median value. The median filter does not require convolution. (If the neighbourhood under consideration contains an even number of pixels, the average of the two middle pixel values is used.)

The best known order-statistics filter is the *median filter*, which replaces the value of a pixel by the median of the gray levels in the neighborhood of that pixel

$$\hat{f}(x, y) = \underset{(s,t) \in S_{xy}}{\text{median}} \{g(s, t)\}$$

The original value of the pixel is included in the computation of the median. Median filters are quite popular because, for certain types of random noise they provide excellent noise reduction capabilities, with considerably less blurring than linear smoothing filters of similar size.

Fig. a and b illustrates an example of how the median filter is calculated. The median filter is effective for removing impulse noise such as “salt and pepper noise” which is random occurrences of black and white pixels.

123	127	150	120	100
119	115	134	121	120
111	120	122	125	180
111	119	145	100	200
110	120	120	130	150

(a) Input image

		121		

(b) Filtered image using median filter showing only the centre pixel

The sorted pixel values of the shaded area are: (100, 115, 119, 120, 121, 122, 125, 134 and 145), providing a median value of 121 in the output image.

High pass filter

High pass filters are mainly filters the high frequency components in an image. It is also applied to sharpen the image. The spatial mask of the high pass filter is as follows.

3×3 H.F mask $\frac{-1}{9}\times$

-1	-1	-1
-1	8	-1
-1	-1	-1

From the above figure the sum of the weighted value=0

IV PROPOSED METHODOLOGY

By considering the inefficiency of the existing image enhancement method there is a need to propose a new methodology for finger print image enhancement leads to image quality. Here we propose a novel filtering technique of hybridization of high boost filter with Gaussian filter.

4.1 High boost filtering

A high boost filter is also known as a high frequency emphasis filter. A high boost filter is used to retain some of the low-frequency components to and in the interpretation of a image[1].

In high boost filtering the input image f(m,n) is multiplied by an amplification factor A before subtracting the low pass image are discuss as follows.

High boost =$A \times f(m,n)$ - low pass

Adding and subtracting 1 with the gain factor

High boost = $(A-1)\times f(m,n) + f(m,n)$-low pass

But $f(m,n)$ - low pass= high pass

Highboost= $(\boldsymbol{A-1})\times \boldsymbol{f(m,n)}$ +***high pass***

.. (3)

4.2 Gaussian filter

Gaussian filters are a class of linear smoothing filter with the weights chosen according to the Gaussian functions. Mainly these kind filters are used to smooth the image and to eliminate the Gaussian noises. This formulated as follows.

$$h(m,n) = \left[\frac{1}{\sqrt{2\pi\sigma}} e \frac{m^2}{2\sigma^2}\right] \times \left[\frac{1}{2\pi\sigma} \frac{n^2}{e2\sigma^2}\right]$$

.....(4)

From the above equation 1the Gaussian filter is separable. The Gaussian smoothing filter is very good in noise removal in normal distribution function. This filter is rotationally symmetric the amount of smoothening is all direction. The degree of smoothening is governed by variance T.

In the proposed filtering technique the high boost filter is applied on the input finger print image. The process flow of the proposed filter is presented below.

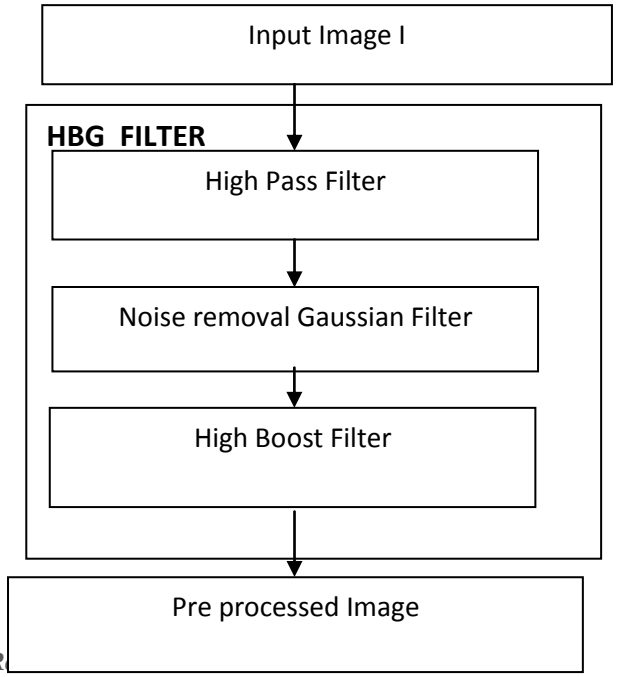


Fig. 4.1 Process flow

From above diagram shows the process flow of the proposed preprocessing technique and the algorithm is shown below**.**

4.3 Algorithm.

Input: original Image

Output: Preprocessed image

Algorithm:

Step 1*: Start*

Step 2 *: Select an Input Image from the IDB*

Step 3*: Preprocess the image by the following*

1. *Apply High pass filter on Input Image*
2. *Noise elimination using Gaussian filter using the equation 4*
3. *Estimate MSE and PSNR*

Step 4.*Apply High Boost filter with amplification factor A=15 on the image obtained from the above step using eqn.3*

Step 5 *: Repeat step 2 to step 4 for all images in IDB.*

V Experimentation & Result

The proposed preprocessing method is experimented with the standard database Db3 of FVC 2004. It contains totally 10 classes of finger prints and each class contains Eight finger prints of same finger from human beings. Totally we have made 10 x 8 computations for each filter. The original images from the experimented database are shown below.

Fig.5.1 Sample images of DB3

The experimentation has done with the finger prints images of the FVC database DB3. The images are experimented and the resultant images are presented below.

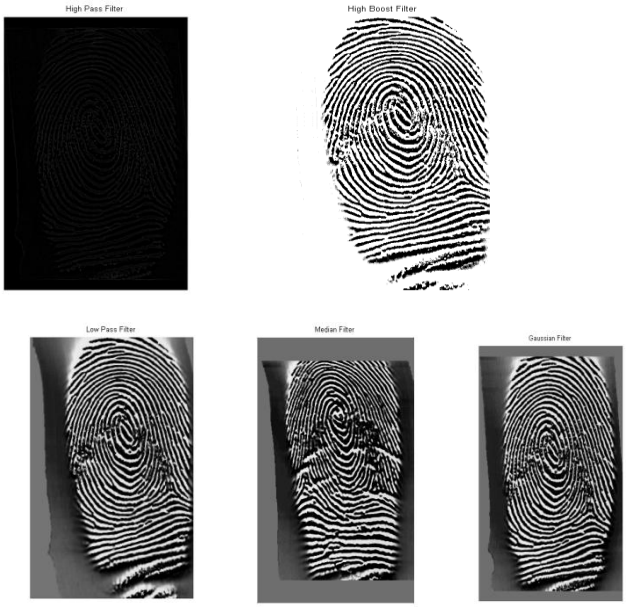


Fig.5.2 Images of HighPass filter b) High Boost Filter

Image ID	High Boost		Gaussian		Proposed HBG	
DB_3	MSE	PSNR	MSE	PSNR	MSE	PSNR
101_2	1.32E+04	10.3747	132.3718	30.3651	8.7195	42.1787
102_5	1.27E+04	10.555	121.0325	30.7546	4.3083	45.2406
103_6	1.34E+04	10.3047	92.9024	31.9034	3.9311	45.6385
104_1	1.24E+04	10.6519	170.897	29.2563	8.5363	42.2709
105_5	1.53E+04	9.7263	145.8843	29.9435	10.1923	41.5009
106_6	1.30E+04	10.4351	122.7408	30.6937	11.7736	40.8746
107_5	1.39E+04	10.14	143.5766	30.0128	12.6089	40.5768
108_2	1.30E+04	10.441	130.84	30.142	11.2102	41.0875
109_3	1.49E+04	9.838	167.788	29.3361	19.0146	38.7929
110_7	1.54E+04	9.7019	155.6496	26.6621	10.4795	41.3802

Fig. 5.3 Output image of Proposed Filter.

From the above fig.5.2 shows the output obtained from the various applied filters such as Low-Pass filter, Median Filter, Gaussian Filter. The proposed pre-processing technique is applied on the images obtained from the combination of High Pass filter and Gaussian filter and finally the High Boost Filter is applied are shown in Figure 5.3. The evaluation of results and the discussions are presented in the following sections.

5.2 Result & Discussions.

The result obtained from the existing as well as the proposed method are show in the following Confusion Matrix Tab.5.1

Table 5.1 Confusion Matrix of Sample Images

Image ID	Low Pass		Median	
DB_3	MSE	PSNR	MSE	PSNR
101_2	207.4192	28.4151	266.2045	27.3315
102_5	118.286	30.8543	266.5883	27.3265
103_6	99.6629	31.5983	204.5362	28.4759
104_1	209.6576	28.3685	371.4486	25.8846
105_5	226.5064	28.0328	426.2734	25.2867
106_6	282.3001	27.0765	396.8191	25.5977
107_5	297.6729	26.8462	464.4716	24.914
108_2	263.0105	27.3839	491.872	24.6651
109_3	359.1322	26.0311	649.4307	23.4583
110_7	283.5517	27.0573	308.0191	26.6478

Table 5.2 Confusion Matrix

Image ID	Gaussian		Proposed HBG	
DB_3	MSE	PSNR	MSE	PSNR
101	107.0019375	31.4050375	5.1832375	44.6432125
102	113.6370625	31.1998125	4.8520875	44.8536875
103	112.872375	31.232975	5.273525	44.8536875
104	132.494325	30.4606	6.914575	44.4375
105	110.4853625	31.251675	8.241759375	42.559725

106	129.242725	30.4879125	10.8659625	41.336225
107	119.85555	30.8284375	10.2822125	41.6200375
108	116.6446875	30.9880125	10.353425	41.6750125
109	149.515775	29.8605625	13.0109	40.6520125
110	157.425125	29.626825	17.0143375	39.6080875

Image ID	Low Pass		Median		High Pass	
DB_3	**MSE**	**PSNR**	**MSE**	**PSNR**	**MSE**	**PSNR**
101	124.8564	30.876963	208.172	28.42321	1.55E+04	9.5323625
102	121.0594	31.025663	271.1923	27.30396	2.35E+06	9.03115
103	129.8792	30.57775	262.5388	27.43478	1.77E+04	9.1198625
104	142.5121	29.522163	344.0819	26.2403	2.31E+07	9.0472375
105	191.4427	29.522163	352.928	26.16155	1.53E+04	9.7545
106	250.7464	24.532088	414.4139	25.49736	1.69E+04	9.279675
107	228.9947	28.1572	413.4695	25.47116	1.62E+04	9.528975
108	230.9259	28.243038	377.3089	25.25795	2.01E+40	9.3799875
109	281.4842	27.194675	419.148	25.60471	1.17E+04	10.5832375
110	350.7432	26.277375	501.5816	24.8389	1.41E+04	10.089375

From the Table 5.1 shows the experimented values obtained from different preprocessing methods. It shows the selected finger print image from the Database. The performance was evaluated using the Mean Square Error (MSE) and Peak Signal Noise Ratio (PSNR) in order evaluate the quality of the image. By the analysis of the values in the table the proposed HBG is better with less MSE and high PSNR values.

In order to evaluate the entire image we have experiment all the images in the image Database DB3 of FVC 2004. The consolidated values from each classes are presented in Table 5.2. From the table 5.2 the values obtained by the proposed HBG model is more efficient.

5.3 Performance Evaluation.

In order to evaluate the performance of the proposed method we have considered the obtained results with the existing Fuzzy based method and other standard filter are shown in the following Table 5.4.

Methods	MSE	PSNR
Proposed	1.1	42.62
Fuzzy Based	6.27E+04	40.49
Gabor Filtering	5.34E+04	15.11
Wernier Filtering	205.26	28.59
Median	356.48	26.22
Gaussian	124.92	30.79

The performance evaluation of the experimentation results are represented in the following Figures

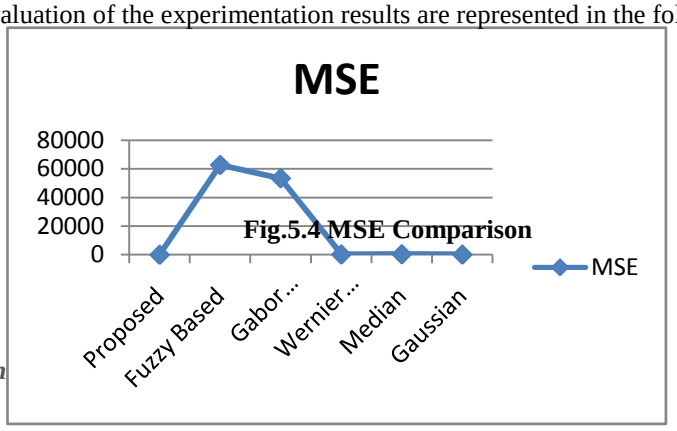
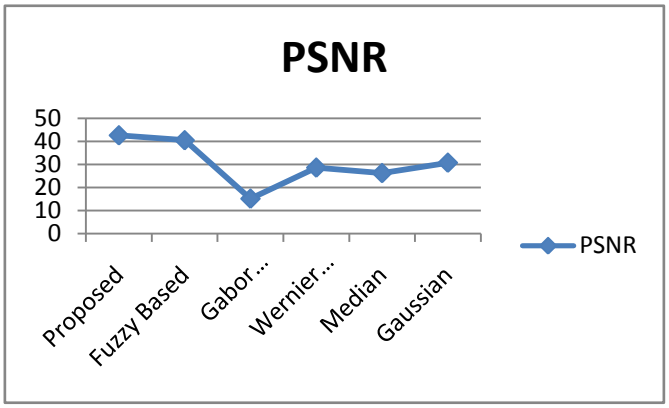


Fig.5.4 MSE Comparison

Fig.5.5 PSNR Comparison



From the above figure 5.4 and 5.5 shows the pictorial representation of the performance evaluated. By analysing the obtained results the proposed model produced the best results. Hence, the proposed method is an efficient one.

VI. CONCLUSION

In this paper an efficient finger print preprocessing method was proposed. Here the image quality plays an important role in FP image enhancement. In order to improve the quality of FP there are various preprocessing methods are available. In this paper we analysed the existing methods and find the draws backs and some issues. In order to over come these issues and get better performance we proposed an efficient methodology for Finger print preprocessing and evaluated by estimating the MSE and PSNR values which are discussed in detail in the earlier sections. By considering all the values we conclude that our propose method is best and an efficient one.

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